Preparation and Status for the Polarized Proton RHIC Run in 2011

- Overall Goal
- Near 3rd Integer Acceleration Test (Au)
- Simulation Effort
- AGS Tune Jump System Commissioning
- Summary

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Problems Observed in Run9 Polarized Protons

250 GeV

- Polarization loss with nominal working point
- Significant polarization profiles in both vertical and horizontal
- Rate Problem of CNI polarimeters
- Polarization life time at store (often could not tell due to rate problem)
- Test of 9 MHz acceleration rf system could not be done with two beams

100 GeV

- Worse efficiency with higher bunch intensity
- Worse luminosity life time at store with smaller β^*

no of bunches	ions/bunch [10^9]	β^* [m]	emittance [μm]	L_{peak} [$cm^{-2}s^{-1}$]	$L_{store\ avg}$ [$cm^{-2}s^{-1}$]	L_{week} [pb^{-1}]
109	110	0.7	18-23	85×10^{30}	55×10^{30}	18.4
Average store polarization: 33% in Blue, 36% in Yellow (online H-jet measurements)						

no of bunches	ions/bunch [10^9]	β^* [m]	emittance [μm]	L_{peak} [$cm^{-2}s^{-1}$]	$L_{store\ avg}$ [$cm^{-2}s^{-1}$]	L_{week} [pb^{-1}]
109	1.1	0.7	14-20	42	20	6.0
Average store polarization: 56 in Blue, 57 in Yellow (online H-jet measurements)						

Address the Problems Seen in Run9

250 GeV

- Develop ramp with tunes near 2/3.
- Vertical survey in RHIC to maintain good orbit control.
- Test the 9 MHz acceleration rf system again with longitudinal dampers
- CNI polarimeter upgrade

100 GeV

- Worse efficiency can be mitigated with 9MHz
- Relax β^* to 0.85m

Projections for Run11 Polarized Protons

- For 100 GeV: **8.3 – 10 pb^{-1}/week, P = 55 – 65%**

Beam β^*=0.85m. 1.3*10^{11}/bunch

- For 250 GeV: **18 – 32 pb^{-1}/week, P = 35 – 50%**

Beam β^*=0.65m. 1.4*10^{11}/bunch

- **The possible gain of polarization is based on the new working point and BPM offset sign reversal.**
- **Before reduce β^*, we will first run dynamic aperture calculation for the new working point.**

Accelerating with Near 3rd Integer Working Point

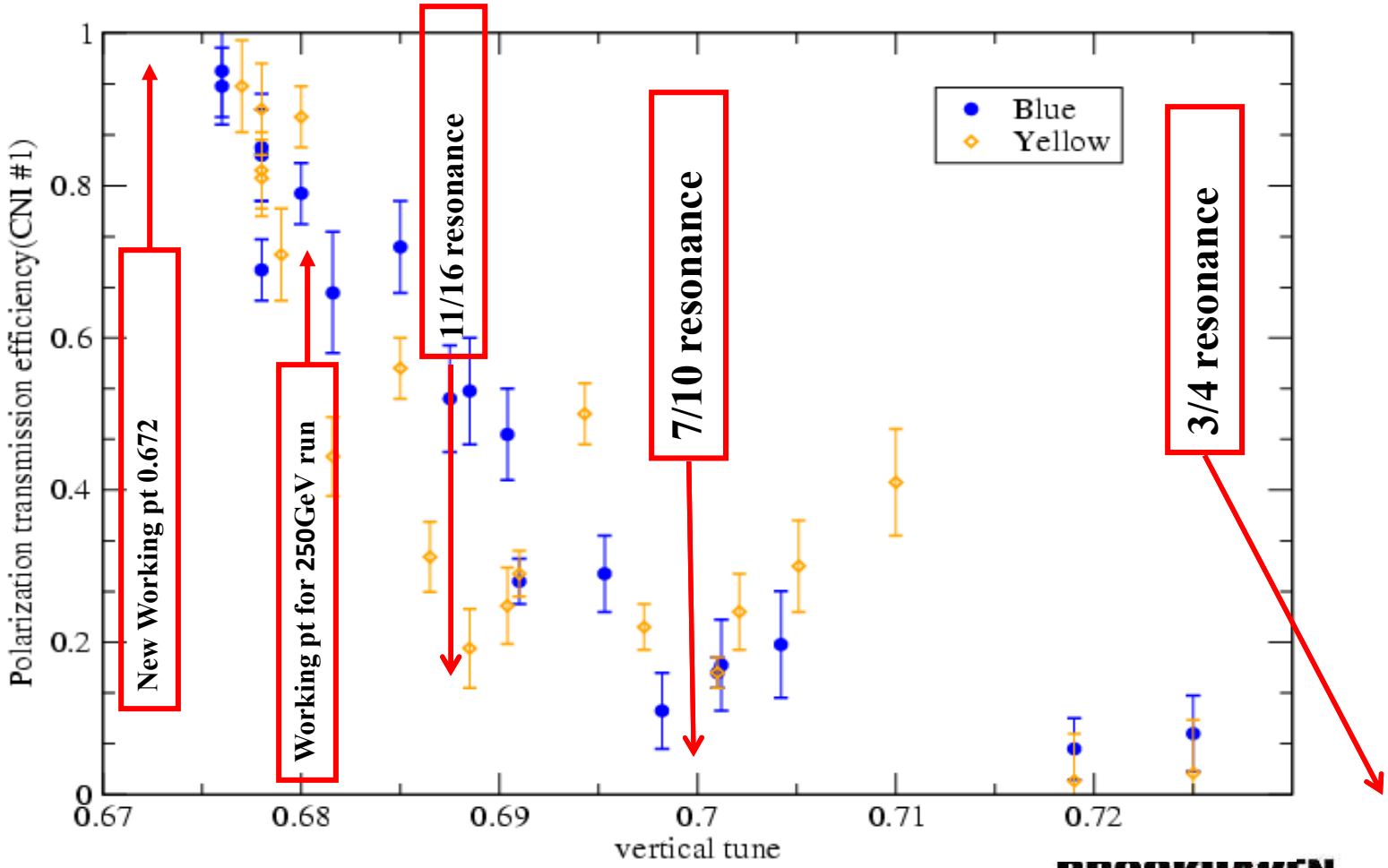
Courtesy of Vincent, Al, Michiko, Steve, Don, Yun, Guillaume, Mei, Todd, Wolfram, Greg

Goal

- Accelerate full intensity beams(>1.0x10^9 bunch intensity, 111x111) to store energy with vertical betatron tune at ~0.005 distance from 1/3
- reproducibility of the ramp

Motivation

- Minimum polarization losses due to the snakes resonances between 100 GeV and 250 GeV



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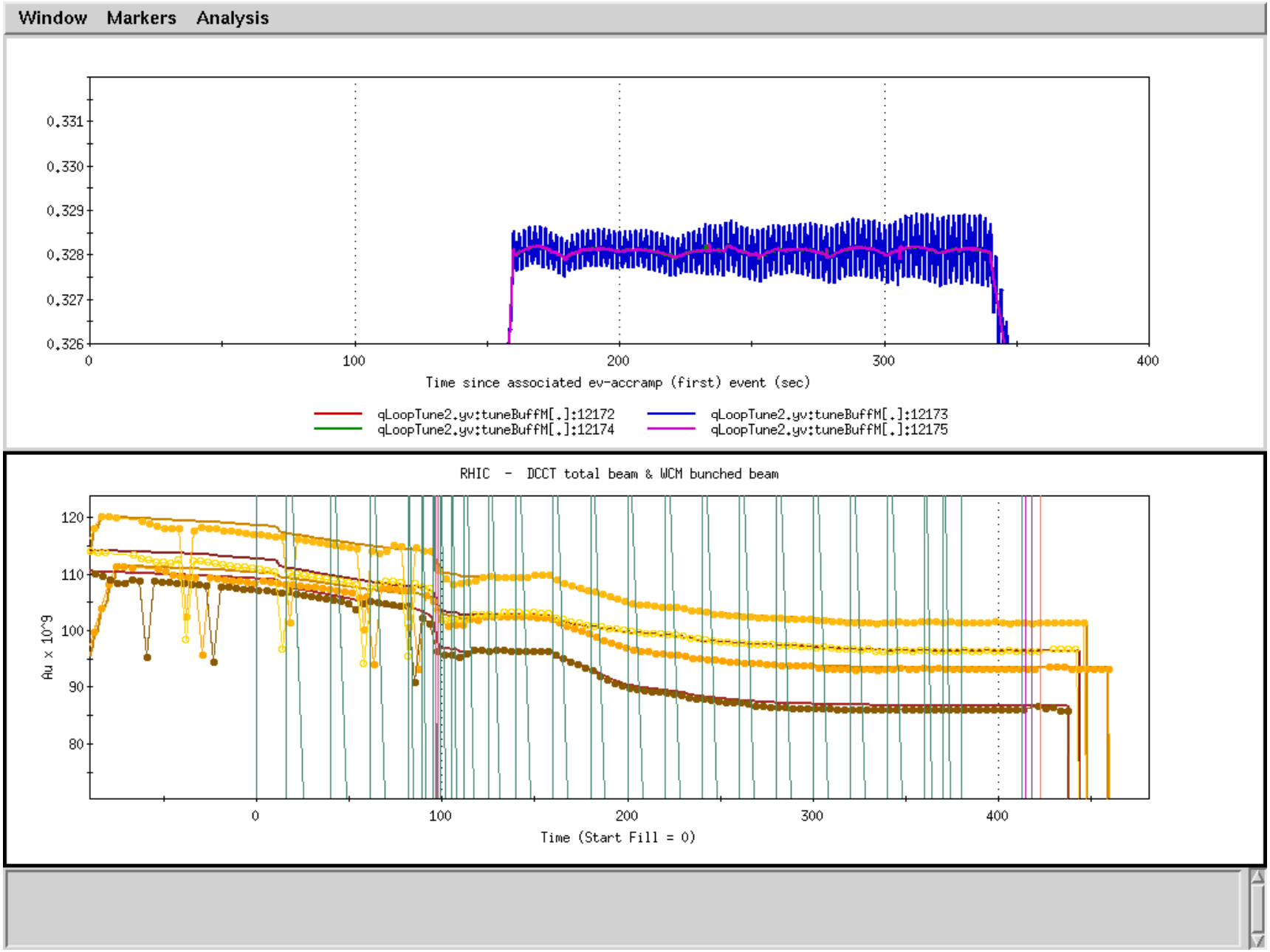
Achieved

- Accelerated 111 Yellow bunches to 100 GeV with vertical tune after tune swing at ~0.005 away from 1/3, with small beta* ~ 2m
- Accelerated 111 Yellow bunches to 100 GeV with 0.2 mm radius wiggling for the whole ramp with vertical tune at 0.328. The closest distance between the modulated of the tune due to non-zero chromaticity reached ~0.0044. This data also demonstrated that this ramp has reasonably tolerance.
- The vertical chromaticity for this part of the ramp was measured to be 2-4 units, a nominal setting for proton acceleration. Bunch intensity was about ~1.1x10^9 ions per bunch at injection.
- Repeated the ramp multiple times to test the robustness of the acceleration with this working point.
- A tune scan at store in Yellow also implied the width of the 1/3 integer resonance is about ~ 0.005 distance.
- Unfortunately, not enough time to improve the Blue transition to a level that it was ready for 111 bunch acceleration.

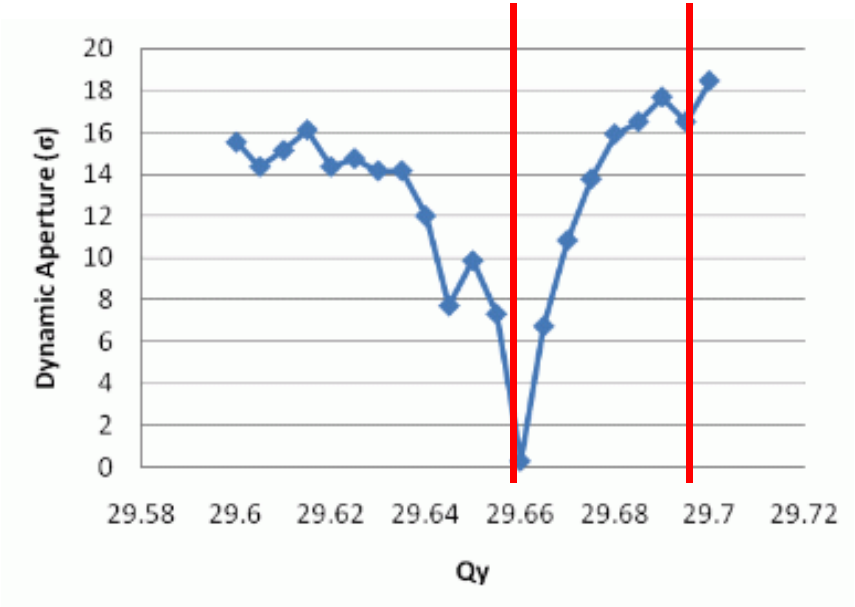
Vertical Tune and Intensity on the Ramp



Simulations Will Follow the Experiment

- Compare the calculated dynamic aperture(DA) the Au lattice used for the third integer working point study and the lattice of the polarized proton 250 GeV (X. Gu, Y. Luo).
- To see whether pp lattice has at least comparable DA as Au IBS suppression lattice.
- More simulation will follow with various beam parameters (intensity, emittances, tunes, beta*).

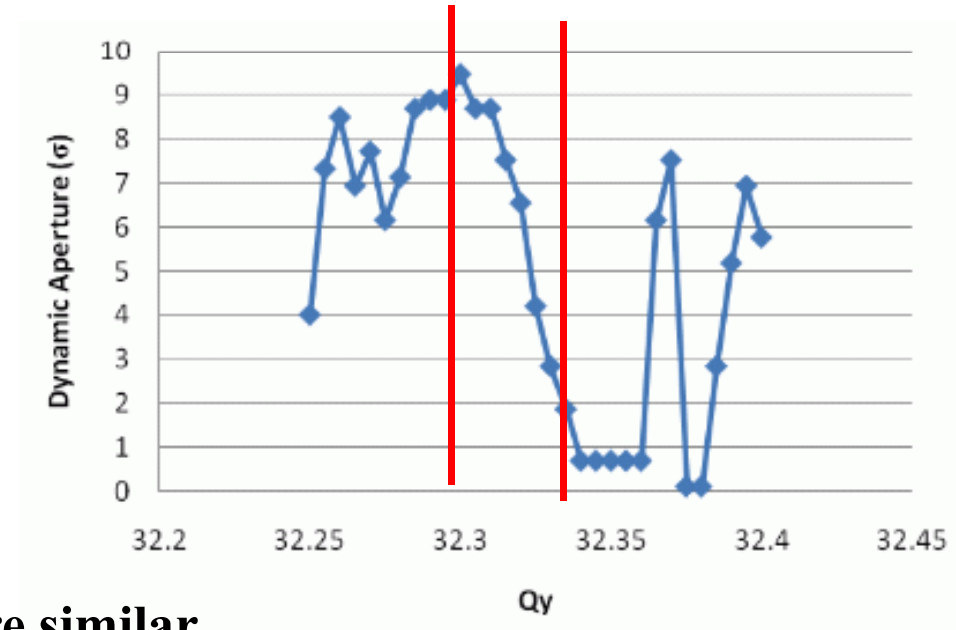
Dynamic Aperture Simulation on the Ramp



(Courtesy of X. Gu & Y. Luo)

← Proton 250GeV Ramp

Au 100GeV Ramp →

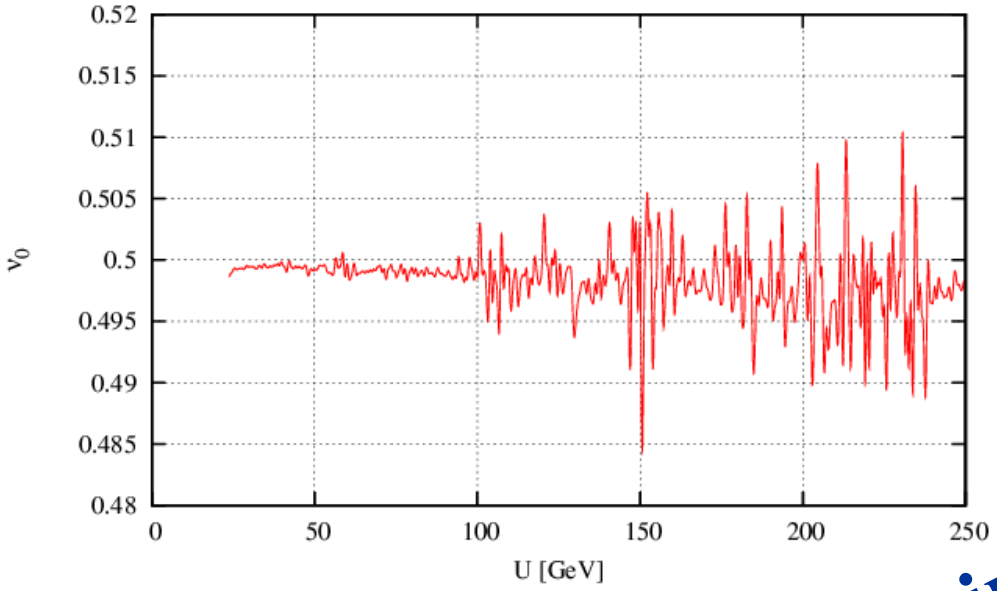


The resonance widths in both cases are similar.

RHIC BPM Offsets

- During run 10, it is confirmed that some of the RHIC BPM offsets are with wrong signs for the past decade. These include all verticals and half of the horizontals.
- It is estimated that the rms values of these offsets are 0.5mm in both horizontal and vertical. As a naïve estimate, it introduces 1mm rms error in the closed orbit.
- This could be a reason for the relative poor polarization transmission efficiency in 250GeV run. For example, the assumed 0.2mm rms vertical closed orbit error can be indeed 1.2mm. Todd and Waldo are working on estimation of the effect.

Spin Tune with BPM Offset Sign Error

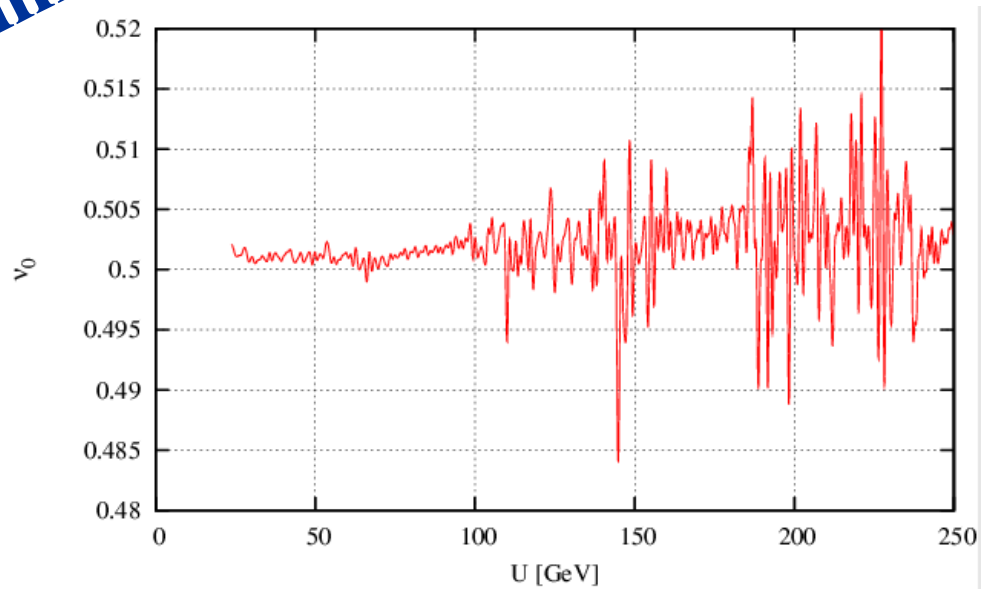


(Courtesy of Waldo)

Yellow Ring

Preliminary

Blue Ring



Spin Tracking Efforts

- The SPINK code has been used for years. It does not have longitudinal part tracking properly.
- Recently, another effort was carried out by Alfredo, Nikolay and Vadim to put SPINK in UAL environment. As the result, the orbit tracking part is based on UAL and spin part remains the same. In addition, the longitudinal part is added properly. The new code has been used to check effect of emittance and momentum spread on spin tune. It is a work in progress.
- The stepwise ray-tracing code ZGOUBI provides a tool to represent the real electro-magnetic fields in the modeling of the optics and spin dynamics. It is also in progress to be applied to RHIC and AGS.

RHIC Vertical Survey

- There has not been RHIC vertical survey for five years.
- Last realignment was done before run6. The year survey of a few places before run6 reveals that the ground is sagging in IP12 over the years. Last vertical survey reveals larger vertical offset up to 5mm.
- It is clear that careful vertical alignment of the RHIC magnets and BPMs is necessary for the 250GeV run.
- We plan to do vertical survey in the summer shutdown. Realignment will follow if survey shows the need.

Horizontal Tune Jump in the AGS

- After introducing the two partial snake in the AGS, the stable spin direction is not vertical. Consequently, the horizontal depolarizing resonances appear. There are 82 of them in the AGS energy range and cause about relative 10% polarization loss.
- To overcome them, a horizontal tune jump system has been installed in the AGS. It can generate 0.04 tune jump in 100μs.
- The keys to the success are: accurate jump timing of all the 82 resonances; preserve emittance with the 82 tune jumps.
- Test the effect at a lower energy flattop at $G\gamma=7.5$. It demonstrated that jump quads on provides better polarization.
- Jump timing scan (overall timing shift) at flattop shows that the polarization is optimized with certain timing.
- Emittance measurements confirmed that emittance was maintained with only a few percents increase. This requires careful adjustment of optics to reduce the beta beats generated by the tune jump quads.

Summary

Planned upgrades for Run-11:

- AGS horizontal tune jump system (Under commissioning)
- Acceleration near 2/3
- Beam dump upgrade
- 10 Hz orbit feedback (demonstrated in run10)
- 9 MHz rf system
- Polarimeter upgrade
- Spin flipper upgrade

Projections for Run-11

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